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WATER AS A TACTICAL WEAPON: A DOCTRINE FOR PREVENTING HEAT CASU--ETC(U)  
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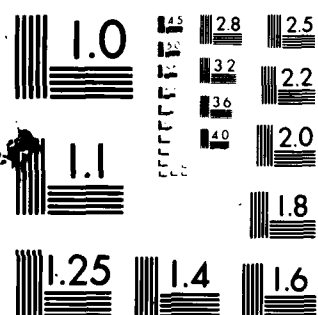
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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER M18/82	2. GOVT ACCESSION NO. AD A113477	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Water As A Tactical Weapon: A Doctrine for Preventing Heat Casualties (U)		5. TYPE OF REPORT & PERIOD COVERED
7. AUTHOR(s) Roger W. Hubbard, Ph.D., Milton Mager, Ph.D., and Morris Kerstein, M.D., CPT, USN-R		6. PERFORMING-ORG. REPORT NUMBER
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Research Institute of Environmental Medicine Natick, MA 01760		8. CONTRACT OR GRANT NUMBER(s)
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Medical Research and Development Command Ft. Detrick, Frederick, MD 21701		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 611102S100Q3E161102BS10 24182101005
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) Same		12. REPORT DATE 1 March 1982
		13. NUMBER OF PAGES 15
		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Distribution of this document is unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) NA		
18. SUPPLEMENTARY NOTES NA		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) NA		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Success in battle during hot weather operations requires maximal operational capability, flexibility, and effectiveness. In order to fulfill mission requirements, individuals must operate at optimal efficiency yet remain free from the serious consequences of dehydration and heat illness. In the past, training and field exercises have often resulted in significant heat injuries. The potential for rapid deployment of large numbers of U. S. Forces to either hot-wet or hot-dry regions of Southwest Asia represents, in itself, a substantial medical threat from endemic disease. A failure to prevent unnecessary		

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Our advocacy of using water as a tactical weapon is based on historical, logistical, physiological and psychological evidence, in addition to personal observations of Army, Marine and Navy units maneuvering at 29 Palms, Ft. Irwin, Camp Lejeune and our experiences at a variety of southern Army posts, the Phillipine Islands, Vietnam, and Israel. New guidelines for the prevention of heat casualties were field-tested ('80 & '81) during large scale tactical maneuvers and found highly effective in meeting both operational and physiological requirements. This proposed doctrine requires field monitoring of environmental conditions with a simple small device (Botsball) by each unit, and increasing individual water intake from 0.5 qt/hr during mild heat conditions (code 1 to 2.0 qt/hr during extreme heat conditions (code 4). During these changes in environmental conditions, simultaneous alterations in work-rest cycles from 50/10 (min) to 20/40 are necessary to maintain body temperatures near normal. With these adjustments, commanders can operate in extremely hot environments, albeit at a slower rate, and complete their mission without undue deterioration of their units' physical and mental capabilities.

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Success in battle during hot weather operations requires maximal operational capability, flexibility, and effectiveness. In order to fulfill mission requirements, individuals must operate at optimal efficiency yet remain free from the serious consequences of dehydration and heat illness. In the past, training and field exercises have often resulted in significant heat injuries. The potential for rapid deployment of large numbers of U. S. Forces to either hot-wet or hot-dry regions of Southwest Asia represents, in itself, a substantial medical threat from endemic disease. A failure to prevent unnecessary heat casualties could result in an unacceptable level of non-battle losses and jeopardize the entire operation.

Our advocacy of using water as a tactical weapon is based on historical, logistical, physiological and psychological evidence, in addition to personal observations of Army, Marine and Navy units maneuvering at 29 Palms, Ft. Irwin, Camp Lejeune and experiences at a variety of southern Army posts, the Phillipine Islands, Vietnam, and Israel. New guidelines for the prevention of heat casualties were field-tested ('80 & '81) during large scale tactical maneuvers and found highly effective in meeting both operational and physiological requirements. This proposed doctrine requires field monitoring of environmental conditions by each unit with a simple small device (Botsball) and increasing individual water intake from 0.5 qt/hr during mild heat conditions (code 1) to 2.0 qt/hr during extreme heat conditions (code 4). During these changes in environmental conditions, simultaneous alterations in work-rest cycles from 50/10 (min) to 20/40 are necessary to maintain body temperatures near normal. With these adjustments, commanders can operate in extremely hot environments, albeit at a slower rate, and complete their missions without undue deterioration of their units' physical and mental capabilities.

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**WATER AS A TACTICAL WEAPON: A DOCTRINE FOR PREVENTING  
HEAT CASUALTIES (U)**

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**INTRODUCTION**

Success in battle requires maximal operational capability, flexibility, and effectiveness under all environmental conditions. The battlefields of the future will require continuous and independent operations around both the compass and the clock with greater emphasis on maneuverability and firepower. The survivability of the modern force will depend on the total and reliable performance of both man and machine; therefore, during hot weather operations, combat crews must operate at optimal efficiency yet remain free of dehydration and heat illness (1).

A number of authors have commented on the impact of heat illness on military campaigns, (2,3) yet, in no prior conflict (WWII to Vietnam) has the true impact of environmental heat on operational effectiveness been adequately measured or documented (4,5,6). According to COL T. F. Wayne (4), Chief Preventive Medicine Division, OSG, 1951, the data on heat injury from of WWII was defective because: 1) We have data only on cases severe enough to be admitted to a medical installation, and milder heat disorders are not recorded. 2) Criteria for diagnosing heat injury were not generally well understood. 3) Heat casualty rates have a seasonal incidence which are biased by the calculation of annual rates. 4) Study of heat injury on a theater rather than unit basis gives a false picture of the potential military problem. Navy monthly morbidity reports appear to confirm that for each case of heat illness admitted to the sick list, there are more than ten unreported cases treated as outpatients (5). In the History of U.S. Marine Corps Operations in World War II (6) is found: "Although several combat commanders believed that they lost as many men to the enervating heat as to enemy fire, no definite count of such casualties existed. Most heat prostration cases were usually treated at the medical aid station close to the front, where no records were kept."

In July 1943, the heat casualty rate in the desert area of the Persian Gulf Command in the Middle Eastern Theater reached 57 per thousand per year (4). This figure suggests a mean weekly incidence rate of 11 per 10,000. According to Terrill (7), "the incidence of heat injury in Vietnam varied from a low of 0.7 per 1000 per

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day in January to a high of 5.4 per 1000 per day in May. These statistics include only those who required treatment by a medical officer for heat injury and include all logistical and support troops, most of whom are never exposed to significant degrees of heat and humidity under stress. More heat casualties occur in combat units and are never documented since they are treated by company aidmen or their buddies." The May rate calculates to a weekly casualty rate of 378 per 10,000 which is nearly 35 times higher than that reported for the Persian Gulf in July 1943. If this rate underestimates the true incidence of heat illness by a factor of 10, we have a significant military heat illness problem. Furthermore, these statistics do not address performance decrements although there is evidence that combat effectiveness would be severely impaired (5).

In 1954, the Navy Bureau of Medicine evaluated a new index of heat stress, the wet-bulb-globe temperature (WBGT). This index integrates the four major climatic variables: temperature, humidity, radiant heat exchange, and air movement into a single number equivalent to the environmental stress. Thermal stress is defined as environmental heat load acting on the body. The impact of the environmental heat load on man's thermal balance is complex because metabolic heat production is another major variable. By estimating dangerous levels of environmental heat stress (WBGT) and then compensating for this heat load by reducing metabolic heat production (work rate), it was thought that the rate of heat illness could be reduced. In 1956, the WBGT index was adopted by the Training Command at Paris Island and subsequently the weekly heat casualties dropped from 39.5 per 10,000 (1952-53) to 12.5 in 1955 and 4.7 in 1956 (6). These data, therefore, indicate that a heat casualty prevention program geared to the WBGT index can be very successful for recruits training at fixed installations.

Unfortunately, heat casualty rates among units participating in combat exercises in tropical and subtropical areas (5) and in the Mojave desert (37 per 1000 per day in 1962) (6) remained high. Many factors contributed to the risk of heat injury (9) including the inability to control the level of physical exertion and the logistical problems resulting in water shortage (5). Following our participation in Brave Shield XVI in 1977, we attempted to identify factors contributing to the high heat casualty rates. An analysis of these factors suggested problems in three general areas: 1) Attitude and doctrine. 2) Water and food logistics and consumption. 3) Work-rest cycles and weather information. Clues to prevailing attitudes and problems were frequently expressed during interviews in the field such as: "You can't stop the war" (work/rest); "Dehydration toughens up the troops" (doctrine); "I need very little water" (voluntary dehydration); "Troops don't need 3 C-rations per day" (salt); "High heat is routine here" (weather) and "Heat casualties are inevitable" (attitude). Further analysis suggested that U.S. Forces could operate effectively in hot weather if Commanders had the information, training and equipment required to adjust work-rest cycles and water intake to the prevailing environmental conditions. In short, we needed simple, rational guidelines relating fluid intake and work-rest cycles to local environmental conditions during combat operations. This presupposed three essentials: 1) a suitable index (WBGT) of environmental stress, 2) a small, light, rugged and inexpensive device for measuring the index (Botsball), and 3) guidelines for relating fluid intake and work-rest cycles

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to the index. Two Marine Corps training exercises, CAX 8-80 and Lancer Eagle, provided the necessary opportunity to test our doctrine. Essentially, we planned to document the number of heat casualties and determine whether the heat casualty rate of selected units could be reduced by a short briefing, use of the Botsball to evaluate the environmental conditions, and modification of work levels and water consumption.

### METHODS

#### Casualty Definition:

A heat casualty is defined as an individual with heat symptoms who fails to function for at least an hour. This represents an individual who reports to a medical facility such as a field hospital or battalion aid station (BAS), for evaluation, treatment and may be returned to duty. In most cases, this took the better part of a day and represented a significant amount of time lost from duty (NonVertical Marine).

#### Casualty Reporting:

CAX-8-80. At the completion of the exercise, medical records (unit LOGS) were reproduced from the following units: Field hospital located at the Brigade Service Support Group (BSSG); Battalion Aid Stations (BAS) located at the Expeditionary Air Field (Air Combat Element, ACE); BAS located at the BSSG; BAS of the 1/24; BAS of the 3/24.

RESPHIBLEX 1-81. Each corpsman from control and test companies were given copies of a medical questionnaire card for collecting heat casualty data, which we collected daily. We recorded heat casualty data admissions to the supporting medical facilities; Boone Clinic, Little Creek, VA; Naval Regional Hospital, Camp Lejeune, NC and the field hospital.

#### Heat Stress Index:

Official WBGT data for the training periods was obtained from Expeditionary Air Field (EAF), 29 Palms, CA; the central weather station, Little Creek, VA; five stations at Camp Lejeune. Botsball readings were taken by the Heat Research Team (HRT) and two test companies (at Little Creek, VA) at hourly intervals, from 0800 to 1600 hours each training day.

#### Training Exercise Description:

The Second Marine Amphibious Brigade (2nd MAB) Combined Arms Exercise 8-80 (CAX 8-80) was carried out entirely on the open desert (Mojave) at 29 Palms, CA, from 2-16 August, 1980. There were 636 officers and 5,374 enlisted reservists (6,010 total) from 110 units in 27 states. The weather was generally hot/dry (120-130°F db) with desert floor temperatures reaching 150 to 180 F. Men were domiciled in tents with food provided in field mess kitchens or as "C" Rations. Water was supplied from stationary, prefixed watering points via tanker trucks and water buffalo.

RESPHIBLEX 1-81, Operation "Lancer Eagle", was conducted by the 43D Marine Amphibious Unit which consisted of various units with a strength of 1150 men. Approximately 700 men of the 3rd Battalion, 5th Regiment, 4th Marine Division trained at Little Creek, VA from 10-18 July 1981 under hot, humid

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conditions. The training varied from lectures in air conditioned rooms to a squad assault on a fortified emplacement during the heat of the day, followed by a night amphibious raid. In other words, the intensity of training varied; periods of rest were bracketed with periods of maximum exertion. The men were domiciled in air-conditioned barracks, meals were provided at either the galley or two field mess sites. Water buffaloes were provided throughout the training area. These units were transported aboard ship (18-20 July). Remaining units of the 43D MAU trained the entire period at Camp Lejeune, NC. From the beach assault until the conclusion of the exercise (21-23 July) men were under field conditions.

#### Experimental Design:

In both exercises, the experimental design was kept simple and consisted of selecting two "high risk" or lead rifle companies as the test group. The two companies selected (CAX 8-80) were Alpha Co., 1st Battalion, 24th Regiment and Kilo Co., 3rd Battalion, 24th Regiment. The remainder of the 2nd MAB served as the control group. During Operation "Lancer Eagle", Lima and Kilo Companies served as the test group. Because of the nature of the training and schedule, two additional companies (Mike and India) served as a control group. The Test Companies received a short 15 minute briefing on the prevention of heat casualties emphasizing the importance of prehydration, drinking by the clock in the absence of thirst, and eating three meals per day. A corpsman was selected to receive additional instructions on the use of the Botsball, all corpsmen were given the Medical Questionnaire cards during Lancer Eagle but not during CAX 8-80. The Commanders of the Test Companies were given provisional heat doctrine cards containing the following simple guidelines:

#### WATER INTAKE, WORK/REST CYCLES DURING FIELD OPERATIONS FOR HEAT ACCLIMATED UNITS

HEAT CONDITION	BOTSBALL WGT <sup>0</sup> (F)*	WATER INTAKE (QT/HR)	WORK/REST CYCLES (MIN)
1. Green	80 <sup>0</sup> - 83 <sup>0</sup>	0.5 to 1.0	50/10
2. Yellow	83 <sup>0</sup> - 86 <sup>0</sup>	1.0 to 1.5	45/15
3. Red	86 <sup>0</sup> - 88 <sup>0</sup>	1.5 to 2.0	30/30
4. Black	88 <sup>0</sup> & Above	2.0	20/40**

\*To convert WGT to WBGT add 2<sup>0</sup>F. Below 80<sup>0</sup> drink up to 0.5 qt/hr, 50/10 work rest cycles.

\*\*Depending on condition of the troops.

#### To Maintain Physical Performance:

1. Drink 1 qt of water in the AM, at each meal, and before any hard work.
2. Frequent drinks are more effective than all at once. Larger men need more water.
3. Replace salt loss by eating 3 rations per day.

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4. As the WGT increases, rest periods must be more frequent, work rate lowered, and loads reduced.
5. Use water as a tactical weapon, and maintain top efficiency by drinking each hour.
  - a) Remember these conditions apply to where the troops are located. For example, the outside temperature is often heat condition 1, but heat condition 4 in an amtrack. Thus, water consumption must increase.
  - b) Meals: The troops must eat the equivalent of 2-3 C-rats per day, as this is how they derive their salt intake. We do not advocate salt supplements unless troops have water but no food.
  - c) Rest: The troops must get 6-7 hours of rest per day (24 hr). This could be obtained by 2-3 hr rest periods if the situation allowed it. For example, the more successful CO's attempted to rest the majority of their troops (70% rest-30% on watch) whenever possible. They rotated troops out of hot vehicles on a more frequent basis.
  - d) The incidence of eye irritations and nose bleeds is probably related to both the drying effects of the air and the prevalence of dust. We eliminated these problems in ourselves by 1) wearing goggles and kerchiefs, 2) washing the eyes and nostrils with water cupped in the palm of one hand as needed.

The Control Companies received the normal preactive duty training which heavily-stressed an awareness of the benefits of overdrinking. In addition, "M" and "I" company corpsmen were given the Medical Questionnaire cards. Their training was guided by the information contained in TB MED 507/NAV MED P-5052-5, Prevention, Treatment and Control of Heat Injury:

#### Use of the WBGT Index in Control of Physical Activity

The proponents of the WBGT index have proposed the following as a standard for application of the index. IT SHOULD BE EMPHASIZED that the measurements must be taken in a location which is the same as, or closely approximates, the environment to which personnel are exposed.

- a. When the WBGT index reaches 78°F (26°C), intense physical exertion may precipitate heat injury, caution should be taken.
- b. When the WBGT index reaches 82°F (28°C) discretion should be used in planning heavy exercise for unseasoned personnel.
- c. When the WBGT index reaches 83°F (29°C), strenuous exercise such as marching at standard cadence should be suspended in unseasoned personnel during their first three weeks of training. At this temperature, training activities may be continued on a reduced scale after the second week of training.

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d. ~~Classes in the sun should be avoided when the WBGT exceeds 85°F (29°C).~~

e. When the WBGT reaches 88°F (31°C), strenuous exercise should be curtailed for trainees with less than 12 weeks training in hot weather. Acclimatized personnel can carry on limited activity at WBGT of 88°F to 90°F (31°C - 32°C) for six hours a day.

f. When the WBGT index is 90°F (32°C) and above, physical training and strenuous exercise should be suspended for all personnel excluding essential commitments.

### RESULTS

During the 15 days (2-16 August, 1980) of the exercise (CAX 8-80) in the Mojave Desert, 1,387 marines reported for sick call or treatment on at least one occasion (1,387 per 6,010 or 23%). In Table 1, we have classified those complaints related to environmental factors

TABLE 1

Number of Heat-Related Cases Recorded by Medical Facility

Facility	Heat Exh.	Head ache	Cramps- Nausea	Nose- Bleed	Eyes
Field Hospital	40	6	13	14	21
BAS-1/24	34	18	6	8	5
BAS-3/24	2	0	0	1	1
BAS-EAF	22	16	2	15	7
BAS-BSSG	12	13	10	8	12
TOTALS	110	53	31	46	46
% Recorded at BAS'S	64%	89%	58%	70%	54%

There were 75 cases of heat illness (Table 1) diagnosed as heat exhaustion or heat reaction, and 35 additional cases of possible heat exhaustion, based on symptoms. Thus, there were 110 cases of treated heat exhaustion lost to the commander for the better part of a day (Non-Vertical Marines). Additionally, there were 176 cases of heat related disorders (Table 1) such as headache, cramps, nausea, nosebleed and eye irritations. These cases represent a large group of marines and should not be overlooked when assessing the impact of the environment on the total force. A greater percentage of casualties (approximately 67%) were treated at battalion aid stations. The total number of heat-related cases was 286 (1 man in 5 reporting to a medical facility had a heat-related disorder). By conservative estimate (4 hours per man), this represents 1,144 man hours lost to duty. The majority are considered preventable illnesses.

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Figure 1 shows that the incidence of headache, cramps, and nausea peaked at day 4 (75% of the cases by day 8), followed by the peak incidence of nosebleed and eye problems at day 5 (73% of the cases by day 8) and heat exhaustion at day 6 (85% by day 8).

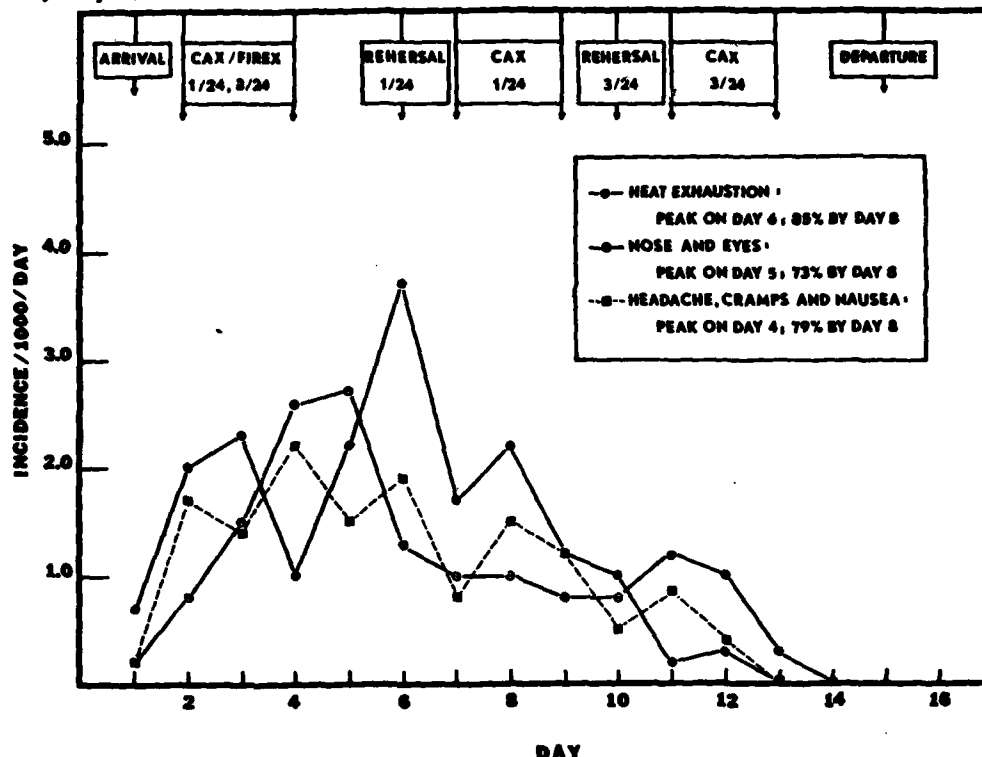


Figure 1. The incidence heat injury during CAX 8-80.

It should be noted that certain features of this exercise were repeated on separate occasions to evaluate their military proficiency. For example, the large scale military maneuver (1st Battalion, 24th Regiment, days 5-9) was repeated on the subsequent four days (3rd Battalion, 24th Regiment).

These data were further summarized as all heat related illnesses (Figure 2), including the effects of heat, low humidity and dust on the incidence of nose and eye problems. The summary of these data suggests a bell-shaped distribution with peak incidence on the 6th day. The only discontinuity in the data occurred on the 7th day of the exercise when a significant proportion of the total force was on or anticipating leave. Two features should be noted: a) the rapid rise in casualty rates through day six; b) the casualty rates for similar activities early on and later in the exercise. For example, note the 6.9 casualty rate for the rehearsal (1/24) on

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day 6 versus the 2.3 casualty rate for the rehearsal (3/24) on day 10. By the same token, note the 4.7 casualty rate for the combined arms exercise (1/24) on day 8 versus the 1.7 casualty rate for the similar exercise (3/24) on day 12.

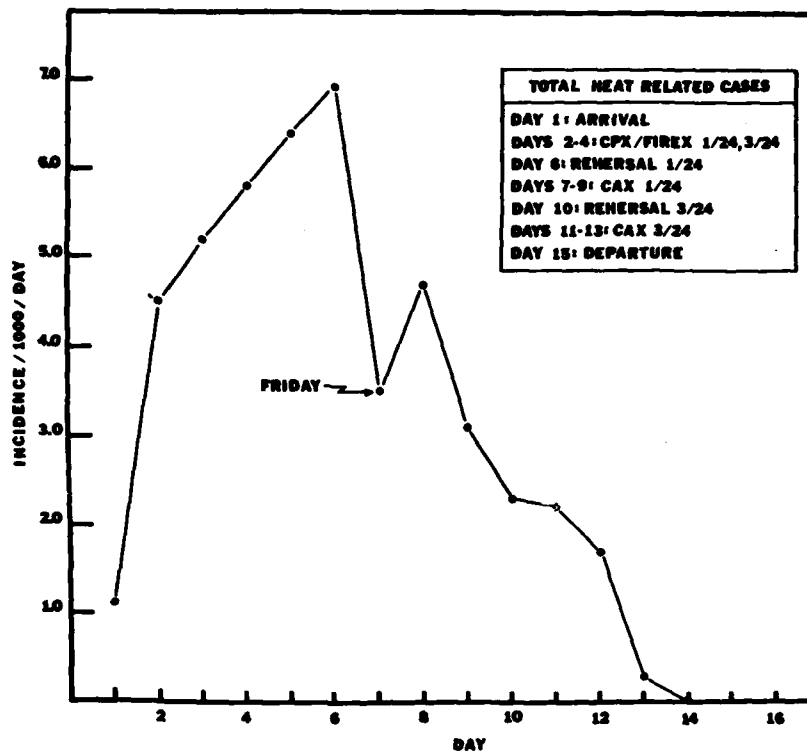


Figure 2. The combined incidence of all heat related cases during CAX 8-80.

The EAF weather station was located between the airstrip and a major road at MCB, 29 Palms while the field hospital located at the BSSG was approximately 4-5 miles down range. The WBGT readings were recorded at the field hospital by members of the HRT. Figure 3 depicts the highest daily WBGT readings taken at the same time of day at the two different locations. Note that the weather station did not begin recording WBGT readings until day 6 of the exercise and the marked variations in WBGT readings between the two sites. The average difference (mean + S.D.) shown in this example was equivalent to  $7.2 \pm 2.3$  degrees.

Kilo Company, 3rd Battalion; 24th Regiment was briefed on 4 August and Alpha Company, 1st Battalion, 24th Regiment was briefed on 5 August. Both companies completed their training without a single heat related casualty including nosebleeds and eye irritation. The CO of Alpha Co recounted his experience with

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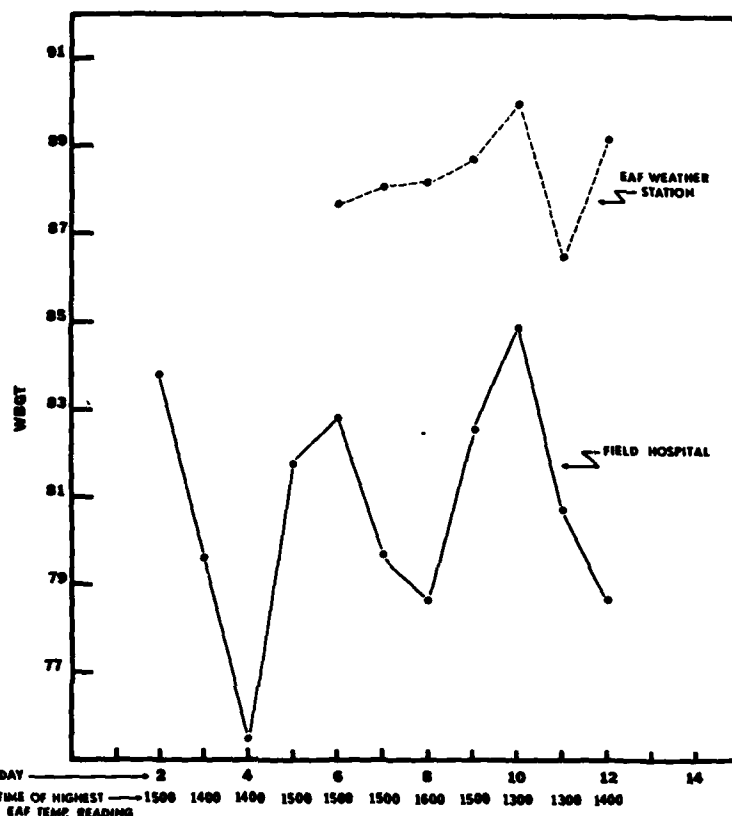


Figure 3. The highest daily WBGT readings recorded at the same time of day from two different sites.

the Botsball and said the instrument was an invaluable asset for adjusting work-rest cycles and fluid intake and had a profound psychological impact on the company. He further explained that the presence and use of the Botsball was a tremendous incentive to the men to continue drinking. It thus became an important "behavior modification" device which made command drinking an easier task to accomplish.

Operation "Lancer Eagle" - From 11-24 July, we collected heat casualty cards on 71 heat cases. There were 20 heat casualties from the "control" companies (I & M) which represents 91 cases per 1000 men (20 per 220 total). Since all casualties for the entire exercise were grouped within six training days (12-15, 21, 22 July), this represents a rate of 15/1000/day. In contrast, there were 13 heat casualties from the "test" companies, 42/1000 men (13 per 306 total). This represents a rate of 7/1000/day.

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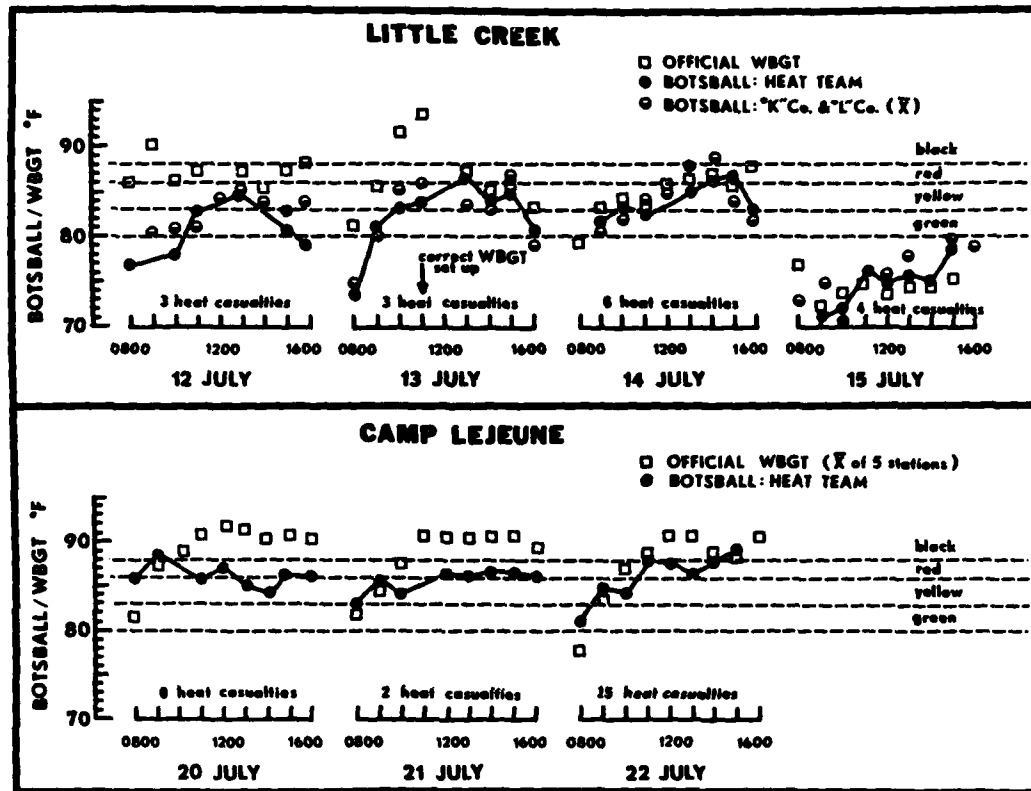


Figure 4. The daily heat casualties and temperatures during Lancer Eagle.

In addition, there were 38 heat cases among units not under our direct observation which were not included in the final statistical analysis. However, an estimate (71/1150/6 days) indicates a rate of 10.3/1000/day which is quite high compared to the desert environment (Figure 2). Approximately 50% of the heat cases within both control and test groups occurred during the training at Little Creek (Figure 4). These cases occurred during short periods of intense activity (1-2h) dictated by the training schedule. Training activities at both Little Creek and Camp Lejeune were subject to modification depending upon the WBGT index. Although the necessary operational procedures and technical facilities to collect and disseminate WBGT data were essentially in place, we discovered factors which, critically impair the effectiveness of the system.

The first involves consisting defining codes for categories of heat stress based on the WBGT index: Condition I, II, or III. At Little Creek, condition I was the most severe (WBGT, 88°F). However, in the operation plan for this exercise, there were four categories based on the WBGT: Condition I, II, III and IV-condition I

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WBGT = 80°F. The operation plan lists the currently accepted condition codes. Nevertheless, a statement received in the field that "...we are in heat condition I" could legitimately be interpreted to mean either "we are in the least or the most dangerous heat condition."

The second involves the quality of the WBGT measurement itself. It soon became apparent to us that the official WBGT readings were significantly higher than our Botsball readings. The magnitude of this difference could not be explained by either the known 2°F difference between Botsball and WBGT readings or any reasonable site variations. A total of six WBGT stations were inspected by us: one at Little Creek and five at Camp Lejeune where we found technically incorrect set-ups of varying magnitude.

The WBGT station at Little Creek was corrected on 13 July. As shown in Figure 4, subsequent data from that station showed good correlation with the Botsball readings. Figure 4 also indicates the number of heat casualties by training day. The 15th of July at Little Creek was the coolest of the training days-- neither the official WBGT nor any of the Botsball readings exceeded 80°F. Nevertheless, four heat casualties were sustained, three of which came from "K" company which had carried out its night raid exercise on the previous night. Also, there may have been additional pressure to complete the training as quickly as possible. The results suggest acute exertion, dehydration and fatigue components in these casualties.

There were no casualties on 20 July with control and test companies still aboard ship. The amphibious landing at Camp Lejeune took place on 21 July. with "Red" Botsball conditions (hot/wet) persisting most of the day. Yet, only two heat casualties were reported during the landing. The level of physical exertion did not approach that required on the "Bridging Beach Obstacles" course at Little Creek.

The day following the landing (22 July) was the hottest day of the exercise and readings had moved into the black range by 1400 hours. Fifteen heat casualties occurred as the troops were pushing inland from the beach against the defending forces. During the assault phase at Camp Lejeune, no Botsball readings were recorded by the test companies' corpsmen. It seems likely that the immediacy of their other medical responsibilities simply took precedence over Botsball data collection.

### DISCUSSION

A consistent feature of this and prior studies (5), was the pride, the motivation and the performance of the individual Marine. It is also a "given" that the combat training was realistic, that the Mojave was hot and dry in August and that the coastal regions of Virginia and North Carolina were hot and humid in July. Furthermore, the total sample size (7,150 individuals at risk) and the number of training days involved (21) appear adequate. Thus, our initial design criteria were met. However, there were differences between this and prior studies which should be borne in mind: 1) we were collecting casualty data from a lower level in the medical chain (the BAS and Corpsman) 2) there was an increased emphasis on water consumption. These two factors would increase and decrease apparent casualty rates, respectively.

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In spite of statistical difficulties, a comparison of casualty rates from the desert area of the Persian Gulf and Vietnam, suggests the likelihood of more heat casualties under hot/wet conditions. There could be a number of reasons for this: 1) The WBGT index might not adequately differentiate between physiological responses to work in humid as compared to dry environments (10), 2) heat dissipation would be limited, especially in the tropics, by the absorptive capacity of the atmosphere or its "cooling power" (11). In other words, sweat evaporation is more difficult under humid, "jungle" conditions and therefore, the heat dissipation rate is only rarely determined by the maximal rate of sweat production (12). It was expected that the peak casualty rate under hot/wet conditions (15 per 1000 per day) exceeded that under hot/dry (6.9 per 1000 per day). Thus, there appears to be a considerable impact of high humidity on the casualty rate. Also, 50% of the heat cases during Lancer Eagle occurred during short periods of intense activity clearly demonstrating the danger of overloading the heat dissipating mechanism under humid conditions.

There is no question that the WBGT index proposed by Yaglou and Minard (13) is effective in reducing heat casualties. Thus, we were concerned not with its theoretical soundness but its application under combat conditions. A number of problems were readily apparent. WBGT readings must be taken in close proximity to the personnel exposed due to variations in temperatures between two locations in the same area (Figure 3). However, the apparatus is cumbersome, fragile and unusable in many situations such as on the march or in tactical vehicles. As a result, the central weather station has been used. This can provide adequate information to a well defined training area, but is unsuitable for most combat scenarios. For example, the weather station did not begin recording WBGT readings until day 6 of the exercise (Figure 3). Moreover if a company commander wanted environmental temperature information he would have to radio his request through headquarters, to RLT HQ to the EAF weather station. The Company CO would receive temperature data for a different location at some prior time. Additionally, its usefulness can be compromised by confusion in the use of codes (see Results) and any errors in estimating the true heat stress index.

Another problem is suggested by examining the current guidelines for the use of the WBGT index in control of physical activity (see Methods). A rapid survey of these guidelines indicates: a) all of the examples relate to training, and presuppose: b) a training plan or prior experience with the effects of the training under cool or moderate conditions, and, therefore, c) command experience and the command control necessary to either reduce, curtail or suspend activity. When applied to combat scenarios, the following situational characteristics are not met: a) local WBGT readings at the site of the activity, b) the ability to suspend activity (the mission usually takes precedence) or c) the ability to predict activity levels for a six hour period (guideline, e).

The potential for having accurate, reliable heat stress information available to the Commander constantly made hour by hour adjustments in fluid intake and work/rest cycles truly feasible. The proposed guidelines for water intake and work/rest cycles represented estimated requirements (1) modified by the known beneficial effects of overhydration (14) and fluid ingestion during prolonged running

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(15). The appropriateness of the work/rest cycles was checked by computer modelling of the predicted rectal temperatures (16).

The emphasis on "Water as a Tactical Weapon" and "Command Drinking" guided by the clock and not by thirst was required for two reasons. The first was to counter the misconception that dehydration toughened up the troops. Various forms of this misguided concept are prevalent at every level of Command. It is not known to what degree a similar Soviet doctrine impacted on the Egyptian Army via their Soviet advisors but intelligence reports indicate that during the 1967 Six-Day War with Israel, the Egyptians suffered 20,000 deaths with no visible wounds (apparently dehydration/heatstroke). During this period, Israeli heat casualties were minimal.

The second reason is based on a wealth of scientific information on the dangers of dehydration which limits sweating, adversely affects cardiovascular and thermoregulatory functions and predisposes to heat illness. The various signs and symptoms of dehydration are well-known and have been adequately described in Adolph's classic text (1). The physiological range of dehydration most important to the military commander is quite narrow, from 2-6% loss of body weight as body water. Thirst usually occurs at a 2% deficit. This is equivalent to approximately 1.5 qts of sweat in the average 75 kg soldier. Battlefield deficits of 2-3% loss of body weight as body water are very common. 5-6% losses represent an upper range, unless water is unavailable since thirst is intense (1). However, body water deficits representing 6-10% of an athlete's body weight can occur during prolonged strenuous sporting events (17). Between 3-5% occur a series of symptoms including vague discomfort, lassitude, weariness, sleepiness and apathy, all of which could clearly impact on the success of a military campaign.

As shown in the following quote by Minard in 1967, there are those within the medical community who feel that heat casualties during hot weather operations are almost inevitable. "Procedures successful in preventing undue heat stress in recruit training, chiefly by reducing metabolic heat load to offset a rise in environmental heat, cannot be applied to combat, since the level of physical exertion is dictated by the tactical situation. Also logistical problems in desert climates may lead to shortage of water and hence water rationing". Note two factors appear critical, the level of physical exertion and the supply of water. A more important factor, voluntary dehydration, was overlooked.

Dehydration, as reported by the Israelis, is one of the major operational causes of heatstroke (18). There are three principal causes of dehydration: 1) Inadequate supplies of water; 2) Depletion of the body's salt content (19). 3) The third cause of dehydration is termed voluntary dehydration. It is due primarily to the inadequacy of the thirst mechanism to monitor or assess the severity of dehydration and to stimulate the amount of drinking required for rehydration. Adolph's research showed that voluntary dehydration increases with sweat rate and, thus, increases with higher ambient temperatures or work rates. It also increases with the temperature of the water and the distance a soldier has to walk to fill his canteen. He is less likely to walk 300 yds for a drink than he is to drink from a water bag hanging close by. Finally, a high percentage of the total deficit occurs during the interval between meals as approximately 44% of the cumulative deficit is replaced during meals (Adolph, 1947).

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The cooling of battlefield water supplies to prevent voluntary dehydration is not a military concept that has been uniformly accepted or practiced. The British, in particular, have taken a stand against it (20). A careful consideration of this report suggests the author's conclusion is not justified and, in fact, provides data to support the concept (20). Cooling and flavoring of water supplies to improve palatability have been demonstrated as an effective substitute for an inadequate thirst mechanism (21). However, during CAX 8-80 and Operation Lancer Eagle, "drinking by command" was the only solution to this problem.

It has been amply demonstrated that acclimatization is extremely important in preserving the ability of troops to function in hot environments (5). The results of many exercises showed high rates of heat casualties occur in nonacclimatized infantry units operating in hot climates during the first week of the operation. The 1967 Six-Day War is a grim example of the potential for disaster. Since the members of the 2nd MAB were drawn from 110 units from 27 states, there was a lack of uniformity in the degree of individual acclimatization. This would necessarily predict, even with an "over drink" policy and with some preexisting acclimatization, a higher heat casualty rate during the first week of the exercise than in the second. As is indicated in Figures 1 and 2, there was a rapid increase in the incidence of heat casualties during the first critical days. It could be argued that the fall in the casualty rate after day six coincided with the availability of accurate heat stress information from the EAF weather station. This seems unlikely, however, since the incidence of headache, cramps and nausea had peaked on day 4 followed by nose and eye problems on day 5.

The test results from CAX 8-80 (zero heat casualties in two "high risk", highly motivated companies) establish the value of the new doctrine in desert combat scenarios. This doctrine will help to prevent heat illness during the acclimatization period of desert operations. It also provides Commanders increased flexibility to deal with environmental conditions during tactical situations. Moreover, their awareness of and emphasis upon their own performance and casualty rates under known heat stress conditions will provide the very best training experience.

Although the test conditions during Operation Lancer Eagle were less than ideal, the heat casualty rates of test companies were reduced 50 percent. Further experience with these new guidelines under hot-wet conditions could produce even better results.

The authors gratefully acknowledge the cooperation and enthusiastic support of the participating military personnel and their units.

The views, opinions, and/or findings contained in this report are those of the author(s) and should not be construed as an official department of the Army position, policy, or decision, unless so designated by other official documentation.

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2. Human subjects participated in these studies after giving their free and informed voluntary consent. Investigators adhered to AR70-25 and USAMRDC Regulation 70-25 on Use of Volunteers in Research.

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